7. Seabird research on Cape Shirreff, Livingston Island, Antarctica, 2000-2001; submitted by Michael R. Taft, Iris M. Saxer, and Wayne Z. Trivelpiece.

7.1 Objectives: The austral summer of 2000-2001 marked the fourth season of land-based predator research conducted by the United States Antarctic Marine Living Resources (AMLR) program at Cape Shirreff, Livingston Island, Antarctica (62° 28'S, 60° 46'W). Through long-term monitoring of krill predator populations, our research on Cape Shirreff contributes to U.S. participation in the international CCAMLR (Convention for the Antarctic Marine Living Resources). Our objectives for the 2000-2001 seabird season were to:

1. To estimate chinstrap and gentoo penguin breeding population size (CCAMLR Ecosystem Monitoring Program (CEMP) Standard Method 3a);

2. To band 1,000 chinstrap and 200 gentoo penguin chicks for demography studies (CEMP Standard Method 4a);

3. To determine chinstrap penguin foraging trip durations during the chick rearing stage of the reproductive cycle (CEMP Standard Method 5a);

4. To determine chinstrap and gentoo penguin breeding success (CEMP Standard Methods 6a, b & c);

5. To determine chinstrap and gentoo penguin chick weights at fledging (CEMP Standard Method 7c);

6. To determine chinstrap and gentoo penguin diet composition, meal size, and krill length frequency distributions via stomach lavage (CEMP Standard Methods 8a,b & c);

7. To determine chinstrap and gentoo breeding chronologies (CEMP Standard Method 9).

7.2 Accomplishments: Four scientists opened the Cape Shirreff field camp on 16 November 2000 with the assistance of the National Science Foundation (NSF) vessel R/V *Laurence M. Gould*, which provided logistical support and transportation from Punta Arenas, Chile to Cape Shirreff. Additionally, the R/V *Yuzhmorgeologiya* brought two scientists ashore on 14 January 2001 with an additional scientist arriving at the Cape on 11 February 2001. Research continued until camp closure on 28 February 2001 when the U.S. AMLR-chartered vessel R/V *Yuzhmorgeologiya* furnished logistical support and passage from Cape Shirreff to Punta Arenas, Chile.

7.3 Results and Conclusions:

Breeding Biology Studies

The penguin rookery at Cape Shirreff is comprised of 29 active breeding colonies of penguins: 16 chinstrap penguin (*Pygoscelis antarctica*) colonies, seven gentoo penguin (*P. papua*) colonies, and six colonies with both penguin species. To determine penguin breeding population

size, we counted all breeding pairs in all colonies approximately one week after the peak clutch initiation date for both species. Gentoo penguins were censused on 27 November and chinstrap penguins on 3 and 4 December. A total of 7,212 chinstrap and 1,043 gentoo penguin pairs bred at Cape Shirreff during the 2000/01 season. Penguin populations have been censused at Cape Shirreff annually since 1997/98. The 2000/01 population counts represent the lowest chinstrap penguin count on record, while the gentoo penguin census was the highest population count to date.

We determined reproductive success by banding and following a sample of 100 chinstrap and 50 gentoo penguin pairs, from egg-laying until the time chicks entered crèches. The mean nest initiation date for chinstrap penguins was 20 November and ranged from 14-29 November. Gentoo penguins nested earlier, with a mean clutch initiation date of 17 November and a range from 7-25 November. The incubation for both chinstrap and gentoo penguins is very fixed, ranging from 36-37 days from the laying of the first egg to the hatching of the first chick. When the nests of both species hatched chicks, the team was able to back calculate the lay dates using the 36-37 day known incubation period; hence the data showing that the earliest breeders initiated clutches prior to the arrival of the scientific team at the Cape. Mean chinstrap and gentoo penguin clutch initiation dates coincided exactly with dates in 1999/00. Chinstrap penguins hatched 1.40 chicks per pair, fledged 1.26 chicks per pair, and 88% of all chicks that hatched survived to fledging. Gentoo penguins hatched 1.62 chicks per pair, fledged 1.36 chicks per pair, and 84% of all chicks that hatched survived to fledging. Chinstrap penguin reproductive success in 2000/01 was within the four-year range, however, the survival of chicks from hatching to fledging was the highest ever recorded. Gentoo penguin reproductive success was also within the four-year averages.

We conducted the annual chinstrap and gentoo penguin chick censuses on 5-6 February and 25 January 2001, respectively. A total of 9,744 chinstrap and 1,298 gentoo penguin chicks survived to crèche age this breeding season. For both species, this season represented the largest number of chicks counted at Cape Shirreff in five years.

As part of our ongoing demographic study, we banded a sample of 1,000 chinstrap penguin chicks on 12 February, and 200 gentoo penguin chicks on 10 February. This season we had a large number of known-age chinstrap and gentoo penguins breeding in the colonies. Future demographic data will continue to be collected on these and other known-age birds as they return to the rookery to establish territories, select mates and breed.

From 16-25 February, we captured and weighed a sample of 198 chinstrap penguin chicks as they congregated on rookery beaches in preparation for fledging to sea. The mean chinstrap penguin chick fledging weight for the season was 3,166g, the lowest in five years. However, the peak of fledging occurred during a severe three-day windstorm that suspended all scientific activity until the storm passed, and this may have biased these results. In addition, we weighed gentoo penguin chicks for comparisons of chick masses among years. Gentoo penguins do not have a fledging exodus, but rather receive supplemental feedings by their parents after their first at-sea foraging trips. We therefore obtain an annual index of gentoo penguin chick mass by weighing chicks at a standard 85 days following the mean clutch initiation date each year. Chicks are approximately seven weeks old at this time, the age at which the other two species of

Pygoscelis penguins fledge. We weighed 200 gentoo penguin chicks on 10 February 2001. The average weight for this sample was 4,509g, the heaviest mean weight over the last four seasons.

Foraging Ecology Studies

We collected 40 chinstrap and 20 gentoo penguin diet samples between 7 January and 11 February 2001 to determine the meal size and prey composition of food delivered to chicks by foraging adults. All sampled adults were verified breeders, as individuals were captured at their nest sites just prior to feeding their chicks. Stomach contents were removed by lavaging, sorted into prey types and weighed separately to the nearest 0.1 grams. The dominant prey species in all diet samples was krill (*Euphasia suberba*), which we found in 100% of samples from both chinstrap and gentoo penguins. Chinstrap penguin diets consisted solely of krill, whereas gentoo penguins ate both krill and fish. We used otoliths collected from gentoo penguin samples to identify fish species in their diets. Analysis of the length-frequency distribution of krill in the penguin's diets revealed that over 90% of all krill in the samples were from three CCAMLR size classes: 46-50, 51-55, and 56+mm. These krill are believed to be from the strong 1994/95 cohort that has dominated the diets of the penguin species at Cape Shirreff for the last 4 years (Figure 7.1).

To determine foraging trip durations during the chick-rearing phase, we attached 19 radio transmitters to adult chinstrap penguins with one week-old chicks during the first week in January and tracked their foraging trips until chicks fledged in late February. All data were received by a remote antenna and stored by a field computer located at our bird blind in the penguin rookery. Similar to the previous three seasons, the 2000/01 season foraging pattern displayed a bimodal distribution. This bimodal pattern is attributed to chinstrap penguins undertaking two types of foraging trips related to breeding energetics: one of shorter duration, one longer. This season, we observed a 2-hour decrease in the duration of short-trips, and a >1 hour decrease in the duration of long trips compared to the 1999/00 pattern. The average duration of foraging trips was the shortest in four years. The short foraging trip patterns this season may be attributed to the abundance of larger krill inshore. As mentioned above, penguin diet samples contained krill of a larger body size than in previous years (Table 7.1). We hypothesize that penguins spent less time foraging because the larger krill available meant fewer dives were needed to gather a full stomach load of food for chicks.

To gather additional at-sea foraging data, we outfitted chinstrap penguins with satellite-linked transmitters (PTTs) during two periods in their reproductive cycle: 1) after clutch completion, and 2) during chick-rearing. In November, we attached four PTTs to breeding female chinstrap penguins after the first egg was laid but prior to clutch completion. We were interested in the location and duration of the female's first foraging trip to sea after clutch completion. Upon returning to their nest after their first foraging trip, we removed their PTTs. Our preliminary data suggested the females had short trips to sea and remained near the rookery, which may indicate nearshore food resources were abundant. On 24 January, we redeployed the four PTTs on chinstrap penguin adults to determine adult foraging locations during the chick-rearing phase. The timing of this deployment coincided with the annual AMLR marine prey survey conducted in adjacent ocean waters. The PTTs remained on the birds for approximately 10 days before removal. Plots of the PTT location data indicated that all birds foraged within 10km of the

colony. The AMLR marine, acoustical survey conducted during this period found large krill swarms within 5-10km of the colony in the areas frequented by the foraging penguins.

To study penguin diving behavior during the chick-rearing phase, we placed nine time-depth recorders (TDRs) on adult chinstrap penguins with chicks. The timing of the deployment (24 January) coincided with the AMLR marine prey survey. The TDRs gathered data on variables such as the dive depth, dive duration, time, and sea temperature. We are currently analyzing data on penguin foraging locations and diving profiles collected by satellite-linked transmitters and time-depth recorders, respectively.

In addition to our penguin research, we studied the breeding biology of the brown skua (*Catharacta antarctica lonnbergi*). Brown skuas are key predators on the Cape Shirreff penguin populations. Penguin eggs and chicks provide a major food source for brown skuas during the breeding season. Throughout the season, we followed the reproductive success of all brown skua breeding pairs (n=21) on Cape Shirreff and one territory off the cape. We have banded all breeding brown skuas in previous seasons and we banded all brown skua chicks produced in the 2000-01 year. Brown skua chicks begin returning to their natal grounds as three-year-olds. We began banding chicks in the 1996/97 season and in 1999/00, we observed six known-age chicks that returned to Cape Shirreff as adults. In the 2000/01 season we had a total of 12 known-age skuas return. It was the first time seven of these skuas had returned since being banded as chicks at Cape Shirreff. We also followed reproductive performance of kelp gulls (*Larus dominicanus*) opportunistically throughout the season.

7.3 Future Research: Our future research plans include the continuation of the annual CCAMLR predator monitoring protocols and at sea foraging behavior studies with TDRs and PTTs. These methods, in association with the Antarctic fur seal research at Cape Shirreff, and the annual AMLR marine prey survey, will allow us to further investigate and gain insight on the seasonal and inter-annual variability of the krill and predator populations in this region.

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Table 7.1. Mean length of krill 2mm and greater from chinstrap and gentoo penguin diet samples at Cape Shirreff, Livingston Island, Antarctica, 1997-2001.

Year	Number of krill measured	Mean length ± SD
1997/98	2,371	39.00 ± 4.00
1998/98	2,454	44.07 ± 3.59
1999/00	2,617	47.71 ± 4.45
2000/01	2,539	50.92 ± 4.72
Overall[a]	9,981	45.54 ± 6.14

a All four years (1997-2001) of data combined.

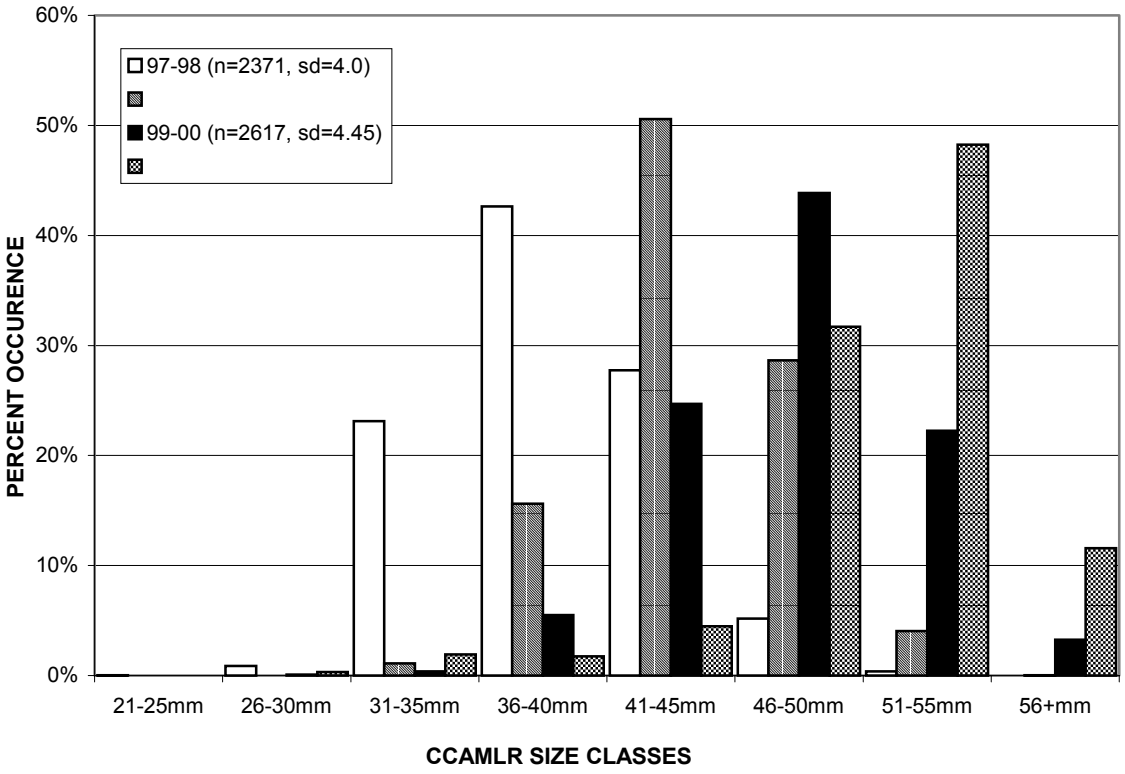

Figure 7.1. Krill length-frequency distribution from chinstrap and gentoo penguin diet samples at Cape Shirreff, Livingston Island, Antarctica 1997-2001.